are asked how large the moon looks, each will give a different answer. One may say that it looks as large as a dime, another that it seems as large as a saucer, while a third may say that it looks as large as a cart wheel. Then, too, the moon looks larger to every one when it is near the horizon than when it is high in the sky.

Infants reach for the moon and cry because they can not get it. Landsmen find it very difficult to estimate the distance between two boats at sea. On the other hand, when we look at a man climbing a distant hill, he appears as but a small speck on the landscape, yet we estimate his size correctly. We even use our knowledge of the man's size to estimate the distance or actual size of the hill or the height of the trees there. Ability to estimate distances and sizes from the way things look is obtained from long practise. Let us see if we can find the reasons for these things.

When sunlight streams through the window, it traces an outline of the window on the floor. If you hold your open hand so that the sunlight falls vertically upon it, the outline of the shadow cast on the floor resembles the outline of the hand. Most of us have amused ourselves making shadow pictures, by so placing the hands between a lamp and the wall that the shadow on the wall resembled a rabbit, a goose, a clown, or any other creature. We might draw the same outline by pivoting one end of a long straight pencil at the source of light, and moving it around the edges of the object, while the other end marked on a paper suitably placed. We can think of such a pencil as if it were the beam from a tiny searchlight moving about the edges of the object and tracing the outline.

When a sunbeam is allowed to enter a darkened room through a small opening, its path, as revealed by the dust particles in the air, is seen to be a straight line. Where it falls on some object it makes a bright spot. The sun, the opening, and the bright spot all lie on the same straight line; so from inside the darkened room we can determine the direction of the sun with reference to objects in the room, by means of the line drawn from the center of the bright spot through the center of the opening. Because light travels in straight lines, we judge the direction of an object by observing the direction in which light from the object travels.

Whatever you may think of the relative merits of the three types of method just outlined, it is clear that the only way to bring physics close to daily life is to bring daily life close to physics. The only method that assures the teacher of doing this successfully is that of the practical or concrete philosophy. It is possible that other methods may be more successful when the aim is to prepare students to meet past or present college entrance requirements, or to pursue later courses in some of the technical schools. Other methods can not, however, compete with the concrete method when the aim of the teaching is the union of education and life. Each teacher must, therefore, choose his own aim and adapt his methods to suit it. Let me in closing remind you of the importance of the choice. Had education and life been united long ago, the schools would not now stand discredited, nor would the demand for separate vocational schools have arisen. A union now of education and life will save the situation.

C. R. Mann

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ON THE APPEARANCE OF HELIUM AND NEON IN VACUUM TUBES[1]

At the last meeting of the Chemical Society, Sir William Ramsay, Prof. Collie,

[1] From *Nature*.

and Mr. Patterson described some experiments which they regard as proving the transmutation of other elements into helium and neon. I have been making experiments of a somewhat similar character for some time, and though the investigation is not yet finished, the results I have obtained up to the present time seem to me in favor of a different explanation from that put forward at the Chemical Society. I described some of these experiments in a lecture at the Royal Institution on January 17, but as the separate copies of that lecture have not yet been issued, I will give here an account of some of the experiments which seem to me to have the most direct bearing on the phenomenon in question.

I used the method of positive rays to detect the gases; this method is more sensitive than spectrum analysis, and furnishes much more definite information. I may say that the primary object of my experiments was to investigate the origin and properties of a new gas of atomic weight 3, which I shall call X_3, which I discovered by the positive-ray method. This gas, as well as one with an atomic weight 20 (neon?), has appeared sporadically on the photographs taken in the course of the last two years; the discharge in the tube being the ordinary discharge produced by an induction coil through a large bulb furnished with aluminium terminals, and containing gas at a very low pressure. There seems to be no obvious connection between the appearance of either of these lines and the nature of the gas used to fill the tube; the 3 line has appeared when the bulb was filled with hydrogen, with nitrogen, with air, with helium, or with mixtures of hydrogen and oxygen in various proportions; the 20 line when the bulb contained hydrogen, nitrogen, air, hydrochloric acid gas, mixtures of hydrogen and oxygen.

The experiments I made had for their object the discovery of the circumstances which favor the production of X_2, and to test whether it was triatomic hydrogen produced by the discharge, as this is the alternative to its being a new element. I have found that the conditions which lead to a considerable production of X_3 generally give rise to the appearance of helium and neon. Indeed, in the great majority of cases in which I have observed the appearance of traces of helium and neon these gases have been accompanied by larger quantities of X_3; this gas seems to have escaped the notice of the readers of the paper at the Chemical Society. I may mention, too, that along with neon of atomic weight 20 there is a line in these circumstances corresponding to an atomic weight 10 or thereabouts. Though this is probably due to neon with two charges of electricity, it is generally brighter in comparison with the neon line than is usual for the lines corresponding to doubly and singly charged atoms, so that it is not impossible, though perhaps unlikely, that it may be due to a new gas.

The positive rays for the analysis of the gases were produced in a vessel containing gases at a low pressure. I shall call this the testing vessel; the vessel in which the various processes for generating X_3 were tried (the experimenting chamber) was sealed on to the testing vessel, but separated from it by a tap. Thus the pressure in the experimenting chamber was not restricted to being the same as that in the testing vessel, but might have the value which seemed most appropriate for any particular type of experiment. After these experiments were over, the tap was turned and some of the gases from the experimenting chamber let into the testing vessel; a photograph was then taken, and by comparing it with one taken before turning the

tap the new gases present in the experiment chamber could be detected. The processes by which I have hitherto got the most plentiful supply of X_3 are:

(1) By bombarding with kathode rays metals and other bodies.

(2) By the discharge from a Wehnelt kathode through a gas at a low pressure.

(3) By an arc discharge in a gas at a comparatively high pressure.

By far the larger number of the experiments were made by bombarding metals, but I will begin by describing an experiment with the arc, as it raises the question of the origin of these lines in a very direct way. An arc between iron wires passed through hydrogen at about 3 cm. pressure (in this case all the kathode rays would be absorbed quite close to the electrode) for an hour or so, and the gases liberated in the experimenting chamber tested; X_3, helium, and neon were found. The experiment, using the same wires for terminals, was repeated the next day; the three gases were again found. On the next day, still using the same wires, the arc was passed through oxygen; the X_3 line was still there, though much fainter than before; the helium and neon could not be detected with certainty. The next day, using the same terminals, the arc was again passed through oxygen; not one of the lines could be detected. This looks as if these substances were produced by the arc passing through hydrogen. It was found, however, that, still keeping to the same terminals, on pumping the oxygen carefully out and filling up again with hydrogen, the arc through the hydrogen now did not give even a trace of these lines. On replacing the old iron wires by new ones, and sending the arc through the hydrogen, the lines reappeared. This experiment seems to me to point very clearly to the conclusion that these gases were in the terminals to begin with, were removed from them by the long-continued sparking, and were not produced *de novo* by the arc.

In the experiments when the discharge was produced in a tube with a Wehnelt kathode, the potential difference between the terminals was only 220 volts, so that the kathode rays in the tube had only a fraction of the energy they had when the discharge was produced by an induction coil; X_3 and helium appeared when the discharge passed through this tube. I did not detect any neon.

The method which gave X_3 and also the other gases, in the greatest abundance, was to bombard metals, or indeed almost any substance, with kathode rays. The tube used for this purpose had a curved kathode, which focused the rays on a table on which the substance to be bombarded was placed. The substance, round the spot struck by the rays, was generally raised to a bright red heat by the bombardment; the bombardment was as a rule continued for five or six hours at a time. I have got the X_3 line, as a rule, accompanied at first by the helium line, and somewhat less frequently by the neon line, when these following substances (which include nearly all I have tried) were bombarded: iron, nickel, oxide of nickel, zinc, copper, various samples of lead, platinum, two meteorites, and a specimen of black mica given me by Sir James Dewar, which was remarkable for the amount of neon it gave off.

The most abundant supply of X_3 came from platinum, and I will describe an experiment with this metal. A piece of platinum foil was bombarded on four days, and the gases produced each day examined. At the end of the first day's bombardment it was found that the line due to X_3 was very strong, those due to helium and neon weaker, but still quite conspicuous. The gases produced the first day were well

washed out of the tube, and the foil bombarded for a second day. The gases formed proved to be much the same as on the first day; there was no appreciable diminution. The examination of the result of the third day's bombardment showed that the X_3 line had diminished considerably, the lines due to helium and neon perceptibly. When the gases produced on the fourth day's bombardment were examined it was found that the X_3 and helium had diminished to such an extent that the lines were barely visible. I could not see the neon line at all. In this case the helium was not eliminated until the fourth day. In general I have found that the helium disappeared long before the X_3 gas. Thus a piece of old lead I bombarded gave off appreciable quantities of helium from the first day's bombardment, very little on the second day, and none that I could detect on the third or subsequent days. The X_3, on the other hand, came off in considerable quantities up to the end of the experiment, which lasted for six days. I attribute the superior elimination of X_3 in the case of the platinum foil to the fact that during the whole time the bombardment was concentrated on a patch only about 2 mm. in diameter, while the lead melted under the bombardment, so that fresh portions were continually being exposed to the rays. A piece of Kahlbaum's chemically pure lead gave appreciable amounts of X_3 and helium, though not nearly so much as the old lead. I tried some lead which had just been precipitated, but could not detect either X_3 or helium.

In the course of the experiments with old lead I let hydrogen into the experimenting chamber to see if it would increase the amount of X_3, but could not detect any effect. On one occasion I let in oxygen when nickel was bombarded, also without any appreciable effect. I think these experiments are in favor of the view that these gases are present in the metal independently of the bombardment, and are liberated by the action of the kathode rays. They are surprisingly firmly held by the metal, and can not, so far as my experience goes, be got rid of by heating. I kept a piece of lead in a quartz tube boiling in a vacuum for three or four hours, until all but a quarter of the lead had boiled away, and examined the gases given off during this process; neither X_3 nor helium could be detected. I then took the quarter that remained and bombarded it, and got appreciable amounts of X_3 and helium. On a second bombardment the X_3 was visible but the helium had disappeared. As an instance of the way these gases can stick to metals even when in solution or chemical combination, I may mention that though, as I have said, platinum foil after long exposure to kathode rays is freed from these gases, yet I got appreciable quantities of X_3 and helium, though no neon from platinum sponge freshly prepared from platinic chloride.

The reason helium is obtained by heating the glass of old Röntgen-ray bulbs is, I think, that after liberation by the kathode rays, the helium either adheres to the surface or is absorbed in a much looser way than before it was liberated. The question as to how these gases get into the metals is a most interesting one; are they absorbed in the process of manufacture? In this connection it is interesting to note that X_3 does not appear to occur to any appreciable extent in the atmosphere. Sometimes when suffering from the difficulty of clearing out these gases I have been goaded into speculating whether they do not represent the partially abortive attempts of ordinary metals to imitate the behavior of radio-active substance; but whereas in these substances the α particles and the like are emitted with such velocity

that they get clear away from the atom, in ordinary metals they have not sufficient energy to get clear, but cling to the outer parts of the atom, and have to be helped by the kathode rays to escape.

I would like to direct attention to the analogy between the effects just described and an everyday experience with discharge tubes—I mean the difficulty of getting these tubes free from hydrogen when the test is made by a sensitive method like that of the positive rays. Though you may heat the glass of the tube to melting point, may dry the gases by liquid air or cooled charcoal, and free the gases you let into the tube as carefully as you will from hydrogen, you will still get the hydrogen lines by the positive-ray method, even when the bulb has been running several hours a day for nearly a year. The only exception is when oxygen is kept continuously running through the tube, and this, I think, is due, not to lack of liberation of hydrogen, but to the oxygen combining with the small quantity of hydrogen liberated, just as it combines with the mercury vapor and causes the disappearance of the mercury lines. I think this production of hydrogen in the tube is quite analogous to the production of X_3, of helium, and of neon. I have been greatly assisted in the experiments I have described by Mr. F. W. Aston, Trinity College, and Mr. E. Everett.

J. J. Thomson

February 8

THE SMITHSONIAN AFRICAN EXPEDITION

The collections made by the Smithsonian African Expedition under the leadership of Col. Theodore Roosevelt, when received, were distributed to the various departments of the National Museum to which they pertained; the birds were sent to the bird department, the large animals to the mammal department, the plants to the botanical department, and so on. A number of groups of the large mammals have been prepared, and a number of individual specimens mounted for exhibition purposes. Most of the specimens have been placed in the study series, and the duplicates will be distributed by exchange or otherwise.

The groups of large mammals now mounted will shortly be placed on exhibition in the new Museum mammal hall where the larger animals will be exhibited. Those that were on exhibition have been temporarily withdrawn, in order to place them in their proper place in the classification in the hall, which is closed temporarily pending the arrangement of the cases containing the specimens.

It now seems an opportune time to make a final statement relating to the expedition and with this in view the secretary recently communicated with the parties who contributed to the fund, and has thus far received replies from the following that they have no objection to their names being given to the public. In this connection the secretary wishes to state that up to this week Colonel Roosevelt has not known who the contributors were, with the exception of Mr. Carnegie and possibly one or two personal friends.

It has not been the custom of the institution to publish the names of contributors to research work or expeditions conducted under its direction until such enterprise had been completed, and only then when the contributor had no objection to such publication. The contributors include:

Mr. Edward D. Adams, of New York City.
Hon. Robert Bacon, of Boston, Mass.
Mr. Cornelius N. Bliss, of New York.
Mr. James Campbell, of St. Louis, Mo.
Mr. W. Bayard Cutting, of New York City.
Mr. Andrew Carnegie, of New York City.
Mr. Cleveland H. Dodge, of New York City.
Mr. E. H. Gary, of New York City.
Mr. John Hays Hammond, of Washington, D. C.
Col. H. L. Higginson, of Boston, Mass.
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Mr. J. S. Kennedy, of New York.
Mr. Ralph King, of Cleveland, Ohio.
Hon. George von L. Meyer, of Washington, D. C.
Mr. D. O. Mills, of New York.